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A word should be said as to the theoretically important question whether the reciprocal crosses differ in their results. No consistent difference is observable. Eight of the 31 F_1 cows (indicated by an asterisk in table 1) had Guernsey dams while 23 had Holstein dams. In their first lactation period the cows with Guernsey dams gave less milk but more butter-fat, average 6953 pounds of milk, 287 pounds of butter-fat. But in the second lactation period, three cows with Guernsey dams give a little more than the average amount of milk with exactly the average amount of butter-fat. It seems unlikely, therefore, that any sex-linked factors are concerned in the case.

[1] Roberts, Elmer. Correlation between the percentage of fat in cow's milk and the yield. *J. Agric. Res.*, **14**, No. 2, July 8, 1918.

STUDIES OF MAGNITUDES IN STAR CLUSTERS, X. SPECTRAL TYPE B AND THE LOCAL STELLAR SYSTEM

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Communicated by G. E. Hale, August 26, 1919

In an earlier communication[1] it has been suggested that the properties of star-streaming and the observed decrease of stellar density with increasing distance from the sun, as well as other observational phenomena, can be explained if the sun is shown to be not far from the center of a large physically-organized star cluster or cloud, which is imbedded in a typical stellar region of the galactic system. Evidence of the existence of such a local group, intermingled with stars of the galactic field, was found from various sources; in particular, the distribution of the brighter stars of spectral type B directly supported the hypothesis that a much flattened local system, of limited extent, surrounds the sun asymetrically, with its equatorial plane inclined some 12 degrees to the plane of the Milky Way.[2] Until recently we have commonly supposed that this stellar assemblage, which is now called the local cluster, constitutes the major part of the known sidereal system; at present we hold it to be a very minor part of the galactic organization.

The completion at the Harvard College Observatory of the first three volumes of the *Henry Draper Catalogue* of stellar spectra permits examination of the distribution of the fainter B-type stars as a graphical test of the existence, dimensions, and inclination of the local system. Miss Cannon has kindly supplied the proof sheets of the third volume of the catalogue in advance of publication. The region covered by these three volumes is that most important for the present problem, since the spectra of all B stars (down to magnitude 8 or 8.5 and many fainter ones) from zero to nine hours in right ascension are included, and in the later hours of right ascension the stars of the Milky Way and those of the local cluster are much less clearly separated on the face of the sky. This difference in separation in opposite hemispheres results from the fact that the sun is some distance to one side of the central plane of the local cluster, thus giving a conspicuous 'dip' to the encircling inclined belt of cluster stars, which minimizes the separation from the galactic equator in Scorpio and Ophiuchus and exaggerates it the most in Taurus and Orion.

The amount of the apparent separation from the Milky Way for any given galactic longitude naturally depends on the average distance (brightness) of the cluster stars concerned. For those not more than 200 parsecs distant from the sun, the maximum separation from the galactic equator is about 17° in Orion and Taurus, as indicated by the broken curve in all the accompanying figures. For stars at the distance of 400 parsecs, which appears to approximate the equatorial radius of the cluster, the maximum separation is a little less than 14 degrees, as shown by the lightly dotted curve in figure 2.

Right ascension and declination are rectangular coordinates in figure 1, which shows the course of the Milky Way throughout the first thirteen hours of right ascension. The data are taken from *Harvard Annals*, **50**, which was the chief source of information regarding stellar spectra before the appearance of the *Henry Draper Catalogue*. Each plotted point in figure 1 shows the position of a star of spectral type B (the subdivisions B8 and B9 are not classed with the other B's—a customary procedure in statistical discussions of spectra). The full curve represents the galactic equator, that is, the central line of the Milky Way after correction for the small dip due to the sun's position slightly to the north of the galactic plane. The broken curve shows the projection of the plane of the local cluster. The determination of this curve was based upon stars brighter than magnitude 5.5 (*Mt. Wilson Contr.*, No. 157, p. 21); if the stars to the sixth magnitude, as plotted in figure 1, had been used in the computation, it is very probable that the curve would be slightly nearer to the galactic equator.

It is clear at once from figure 1, that these B-type stars are affiliated with the local cluster. We may reasonably assume that about twenty of them, along the galactic plane, may be actual members of the galactic field, and that the other three hundred are members of the subordinate local system, quite unrelated to the plane of the Milky Way. On the

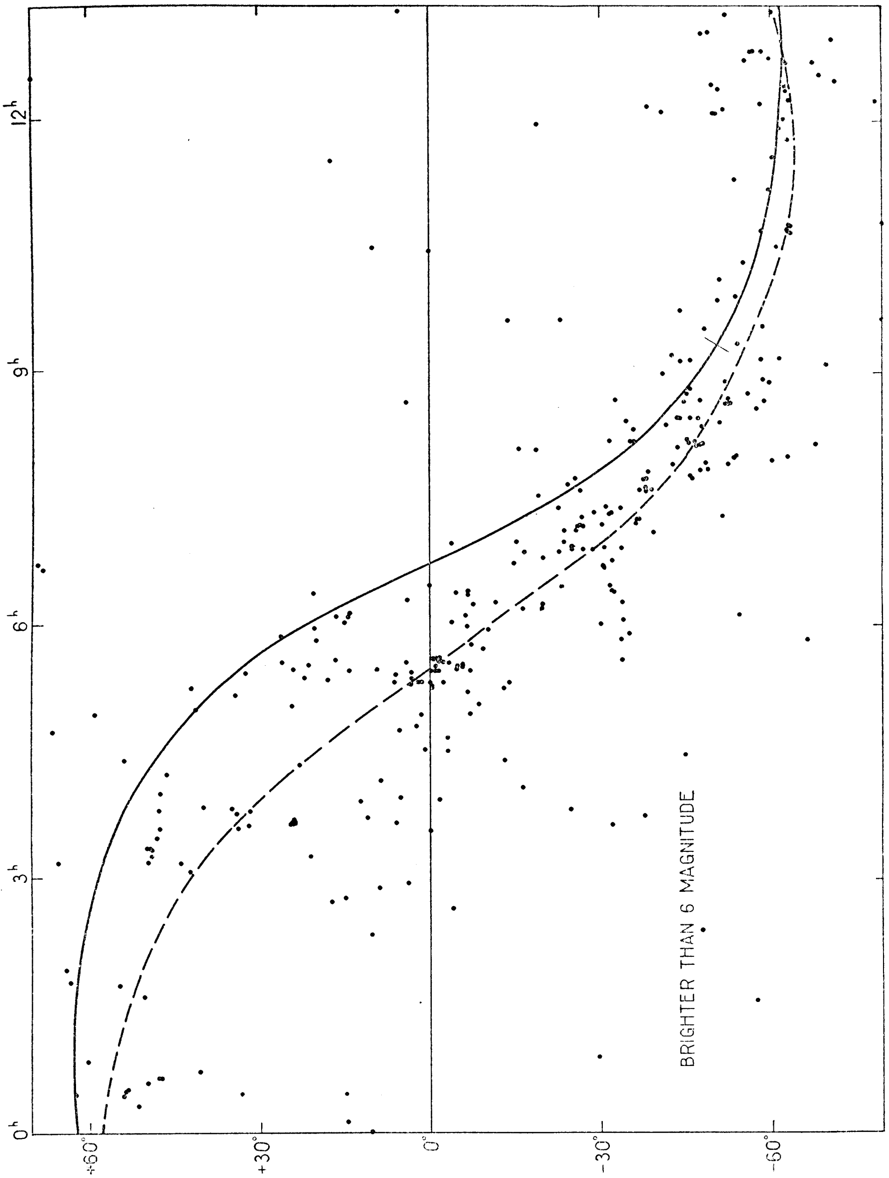

Fig. 1. Distribution of B0–B5 stars, from *Harvard Annals, 50.* In all three figures ordinates are declination, abscissæ are right-ascension. The curves are described in the text.

east side of the Milky Way (in the part of the sky under consideration) there are scarcely any bright B-type stars; on the west there are hundreds of them. The remarkable inequality gives rise to what was called, in an earlier paper, the 'Secondary Galaxy.' This sub-ordinate Milky Way, though well defined by star analyses throughout its complete circuit of the sky, to the naked eye is most clearly seen in the region mapped in figure 1, where it stands out some 10 to 20 degrees along the west side of the Milky Way from Perseus southward through Taurus, Orion, and Canis Major to Puppis and Carina. Not only the very

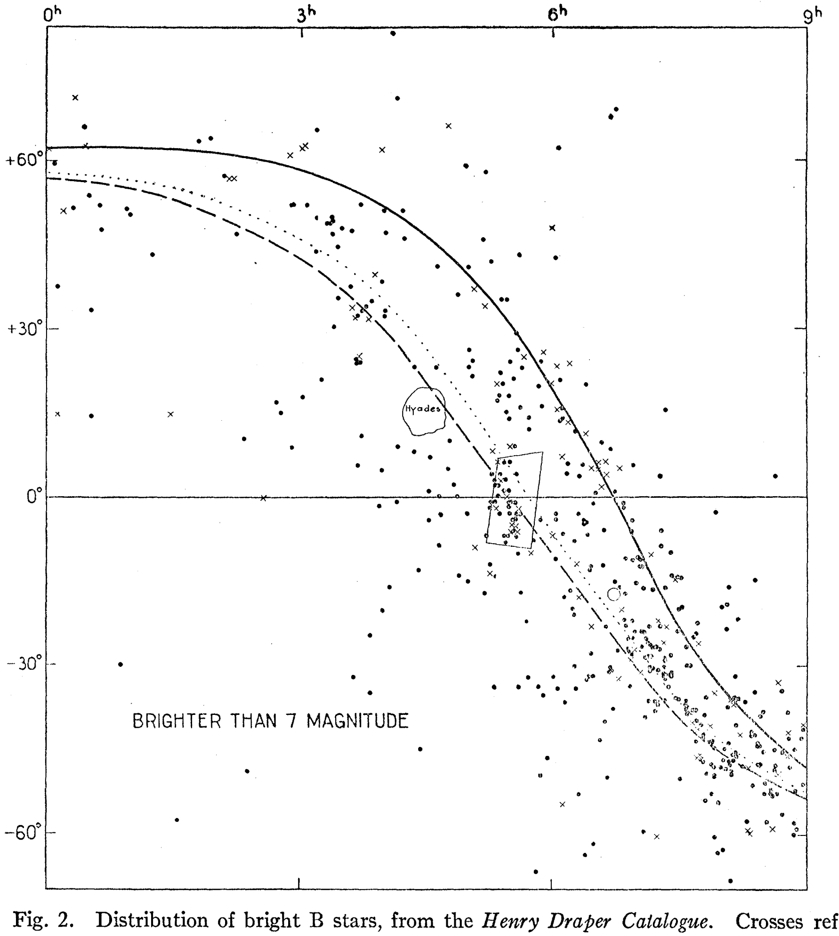

Fig. 2. Distribution of bright B stars, from the *Henry Draper Catalogue*. Crosses refer to sub-types B0, B1, and B2 (and undefined B's); the dots refer to sub-types B3 and B5. The curves are described in the text. The large circle shows the position of Sirius; the trapezoid indicates the constellation Orion. The direction of the center of the local cluster falls near the lower right-hand corner of the diagram.

bright stars of types B and A throughout this region may be assigned to the cluster, but also the rich belt of stars of all types with magnitudes from three to seven. Across from Orion and Canis Major, on the other side of the Milky Way and at the same distance from the galactic equator, we find in Cancer and Hydra no counterpart of this richness in naked-eye stars; and the intervening constellation Monoceros is almost destitute of stars brighter than the sixth magnitude, although it lies along the central line of the Milky Way and is surpassingly bright in telescopic stars of the far-extending galactic segment.

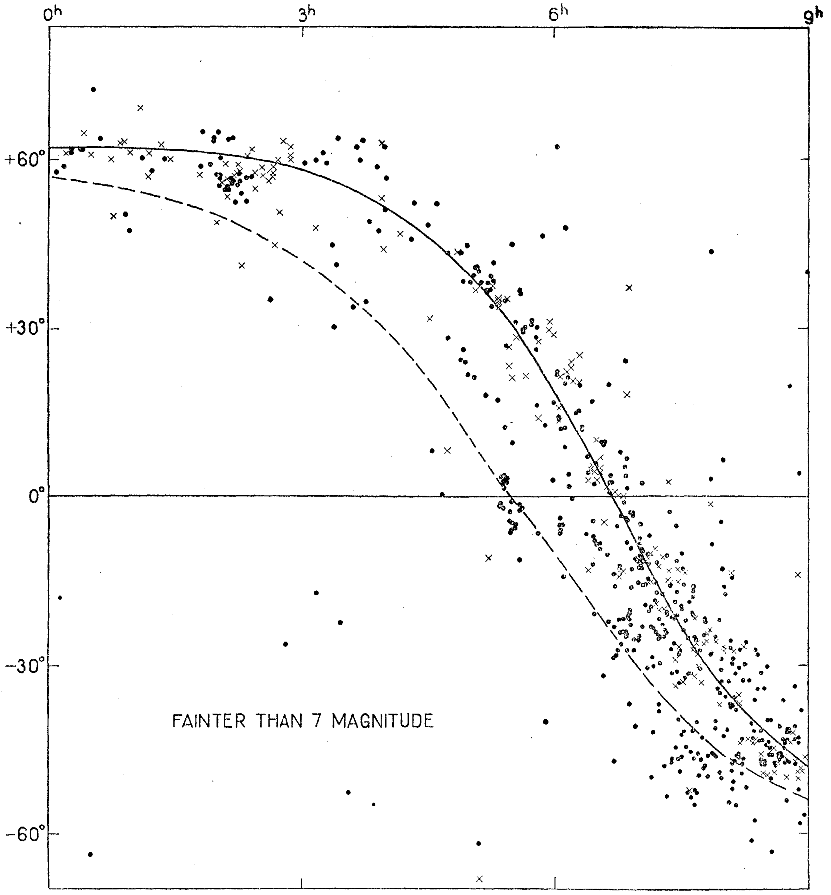

Fig. 3. Distribution of faint B stars, from the *Henry Draper Catalogue*. The wide extent of the bright double cluster in Perseus is shown by the points near declination + 60° and right ascension 2^h.

From the recent studies by Walkey, Charlier, and Strömberg it is known that the center of the stellar system that immediately surrounds the sun is in the general direction of the constellation Carina. The approximate galactic longitude of this center (which is to be taken as the center of the local cluster rather than that of the galactic system) is indicated in figure 1 by the short line across the galactic equator. A greater frequency of stars is to be noted in this direction, especially of the fainter objects plotted in figures 2 and 3.

We recall that Strömberg's researches,[3] through showing that stars of types F, G, and K appear to have motions related to the same center as that determined for the B-type stars, may be taken as strongly supporting the hypothesis of a local cluster which involves all types of stars. The observed decrease of stellar density with distance from the sun, for all the principal spectral classes, is also almost conclusive evidence that the phenomena of the local cluster are not confined to the B stars alone. It appears highly probable, therefore, that the inclination and extent now under investigation refer to the cluster as a whole, and not only to these blue giant stars which, because of their uniformity in absolute brightness and their apparently high concentration to dynamically central planes, are of such high value in outlining a stellar system.

The available volumes of the new catalogue of spectra cover less area than shown in figure 1, but the extension to the seventh magnitude (fig. 2) adds definitely to our knowledge of the cluster. Stars of the seventh magnitude are 1.6 times as far away as those of the sixth when the intrinsic brightness is the same. Increasing the depth of our survey by that amount has therefore brought in many B-type stars of the galactic field, objects concentrated to the galactic equator, and it has not introduced a great many stars of the local system. Hence, there is a suggestion in figure 2 that we are attaining the edges of the local cluster when we go out to the B-type stars of the seventh magnitude.

Extending the survey much deeper into space by including the stars fainter than magnitude 7 (fig. 3), we find that outside the relatively small domain of the local cluster the galactic equator has definitely established itself as the central circle for B-type stars.

The very high concentration of these distant stars to the Milky Way is a striking illustration of the great depth of the galactic system when compared with its extent perpendicular to the galactic plane. Probably the most important inference from figures 2 and 3 is, however, that the galactic field is continuous in the immediate environs of the local cluster—that the latter is not a large group or cloud distinctly and distantly isolated in space from other stellar regions. Similar evidence of a surrounding and intermingling galactic field may be deduced from the distribution of Cepheid variables, N-type stars, planetary nebulae, and similar special classes of sidereal objects.

In figures 2 and 3 the crosses indicate the position of stars of the sub-types B0, B1, and B2, and the dots refer to the sub-types B3 and B5. Stars of the first group of sub-types are believed to be intrinsically brighter than those of the second. For a given apparent magnitude, therefore, their distances are greater—possibly even twice as great. It is to be noted that the crosses have completely left the secondary circle in figure 3, indicating that the local cluster is not large enough to include objects as distant as B1 stars must be when they appear fainter than magnitude 7.

[1] Shapley, Harlow, these PROCEEDINGS, 4, 1918, (224–229); *Mt. Wilson Communications*, No. 54. See also *Mt. Wilson Contr.*, No. 157, and a small modification of the original statement of a star-streaming hypothesis, *Mt. Wilson Contr.*, No. 161, section IX.

[2] For other properties of the local cluster and for a discussion of the peculiar value of B-type stars in describing its extent, form, and orientation, reference may be made to *Mt. Wilson Contr.*, No. 157, part II. and No. 161, section IX.

[3] Strömberg, Gustaf, *Astrophys. J., Chicago, Ill.*, 47, 1918, (7–37); *Mt. Wilson Contr.*, No. 144.

INFLUENCE OF IONS ON THE ELECTRIFICATION AND RATE OF DIFFUSION OF WATER THROUGH MEMBRANES

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1. When pure water is separated from a watery solution by a strictly semipermeable membrane more molecules of water will diffuse through the membrane from the pure solvent to the solution than will diffuse simultaneously in the opposite direction; and this difference in the rate of diffusion of water in the two opposite directions will be the greater the higher the concentration of the solution. When the solution is put under pressure, the number of molecules of water diffusing in the unit of time from the solution into the pure solvent will be increased and if this pressure reaches a certain value the number of molecules of water diffusing simultaneously in opposite directions through the membrane will become equal. We may therefore define the osmotic pressure of the solution as the additional pressure which has to be applied to the solution in order to cause as many molecules of water to diffuse from the solution to the pure solvent as will diffuse simultaneously in the opposite direction.

van't Hoff's theory of osmotic pressure assumes that this quantity depends exclusively upon the concentration of the solution. For some